Human Spaceflight Capabilities

Galvanic Vestibular Stimulation (GVS) as an Analogue of Post-flight Sensorimotor Dysfunction

Completed Technology Project (2008 - 2012)

Project Introduction

Aim 1A (complete): Tolerance to GVS. Dilda, V, MacDougall HG, Moore, ST. Tolerance to extended Galvanic vestibular stimulation: optimal exposure for astronaut training. Aviat Space Environ Med. 2011 82:770-774. Aim 1B (complete): Cognitive effects of GVS. Dilda, V, MacDougall HG, Curthoys IS, Moore, ST. (2012) Effects of Galvanic vestibular stimulation on cognitive function. Exp Brain Res, 216:275-285. Aim 2 (complete): GVS as an analog of post-flight spatial disorientation. Moore ST, Dilda V, MacDougall HG (2011) Galvanic vestibular stimulation as an analog of spatial disorientation after spaceflight. Aviat Space Environ Med, 82; 535-542. Aim 3 (complete): Adaptation to repeated exposures to GVS. Postural and locomotor function recovered in an exponential pattern over 12 weeks of weekly 10-min GVS exposures, and this improvement was maintained at week 18 and 36 follow-ups. The exponential pattern of postural recovery was similar to that observed in shuttle astronauts post-flight. GVS adaptation did not occur at the vestibular end-organs or involve changes in low-level vestibulo-ocular or vestibulo-spinal reflexes. Faced with unreliable vestibular input, the CNS reweighted sensory input to emphasize veridical somatosensory and visual information to regain postural and locomotor function. After a period of recovery subjects exhibited dual adaptation and the ability to rapidly switch between the perturbed and natural vestibular state for up to 6 months, analogous to veteran astronauts. GVS trained subjects performed significantly better than untrained controls ($p=0.01$) on a visuomotor task in a full motion simulator during unpredictable motion, suggesting a protective effect of GVS exposure in novel vestibular environments.

Anticipated Benefits

1. Development of a self-contained ambulatory current generator for the safe application of low-level pseudorandom electrical current between surface-mounted mastoidal electrodes. The GVS system has been evaluated by the Food and Drug Administration and is approved for use as an investigational device for the purpose of replicating sensorimotor effects of gravity transitions. This device is also used by another National Space Biomedical Research Institute (NSBRI) Principal Investigator (PI) (Dr. Mulavara). 2. Preliminary studies demonstrating: adaptation to repeated GVS induces a similar central reweighting of sensory input as that observed in microgravity, resulting in a dual-adapted state (vestibular-perturbed and baseline) analogous to veteran astronauts; rapid switching between states; a protective effect when performing a visuomotor task in a novel vestibular environment; and persistence of dual-adaptation 6 months post-training. This pre-adaptation approach to novel vestibular environment has potential applicability for vestibular patients, utilizing the same 'dual-adaptation' premise. We have begun pilot studies applying our GVS paradigm in patients with intractable vertigo, with promising results (patient reports of diminished dizziness in daily life).

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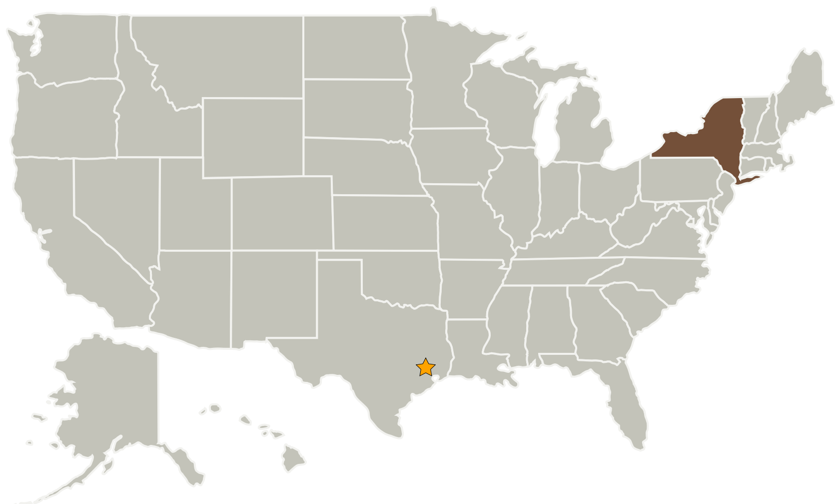
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
☆Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
Icahn School of Medicine at Mount Sinai	Supporting Organization	Academia	New York, New York
University of Sydney	Supporting Organization	Academia	Sydney, Australia

Primary U.S. Work Locations
New York

Project Transitions

May 2008: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Center / Facility:

Johnson Space Center (JSC)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Principal Investigator:

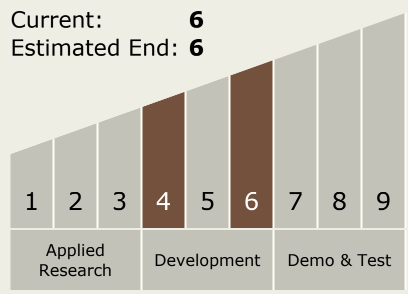
Steven T Moore

Co-Investigators:

Ian Curthoys
Jacob J Bloomberg

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



September 2012: Closed out

Closeout Summary: Aim 1A (complete): Tolerance to GVS. Dilda, V, MacDoug all HG, Moore, ST. Tolerance to extended Galvanic vestibular stimulation: optim al exposure for astronaut training. Aviat Space Environ Med. 2011 82:770-774. Aim 1B (complete): Cognitive effects of GVS. Dilda, V, MacDougall HG, Curthoys IS, Moore, ST. (2012) Effects of Galvanic vestibular stimulation on cognitive fun ction. Exp Brain Res, 216:275-285. Aim 2 (complete): GVS as an analog of post -flight spatial disorientation. Moore ST, Dilda V, MacDougall HG (2011) Galvanic vestibular stimulation as an analog of spatial disorientation after spaceflight. Avi at Space Environ Med, 82; 535-542. Aim 3 (complete): Adaptation to repeated e xposures to GVS. Postural and locomotor function recovered in an exponential p attern over 12 weeks of weekly 10-min GVS exposures, and this improvement w as maintained at week 18 and 36 follow-ups. The exponential pattern of postura l recovery was similar to that observed in shuttle astronauts post-flight. GVS ad aptation did not occur at the vestibular end-organs or involve changes in low-lev el vestibulo-ocular or vestibulo-spinal reflexes. Faced with unreliable vestibular i nput, the CNS reweighted sensory input to emphasize veridical somatosensory a nd visual information to regain postural and locomotor function. After a period o f recovery subjects exhibited dual adaptation and the ability to rapidly switch be tween the perturbed and natural vestibular state for up to 6 months, analogous to veteran astronauts. GVS trained subjects performed significantly better than untrained controls (p=0.01) on a visuomotor task in a full motion simulator duri ng unpredictable motion, suggesting a protective effect of GVS exposure in nove l vestibular environments.

Stories

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8260)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25080)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8259)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25956)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25329)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25902)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/25610)

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/8258)

Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - └ TX06.3 Human Health and Performance
    - └ TX06.3.2 Prevention and Countermeasures

Target Destinations

The Moon, Mars

Awards
(https://techport.nasa.gov/file/24939)

Awards
(https://techport.nasa.gov/file/24937)

Project Website:

https://taskbook.nasaprs.com